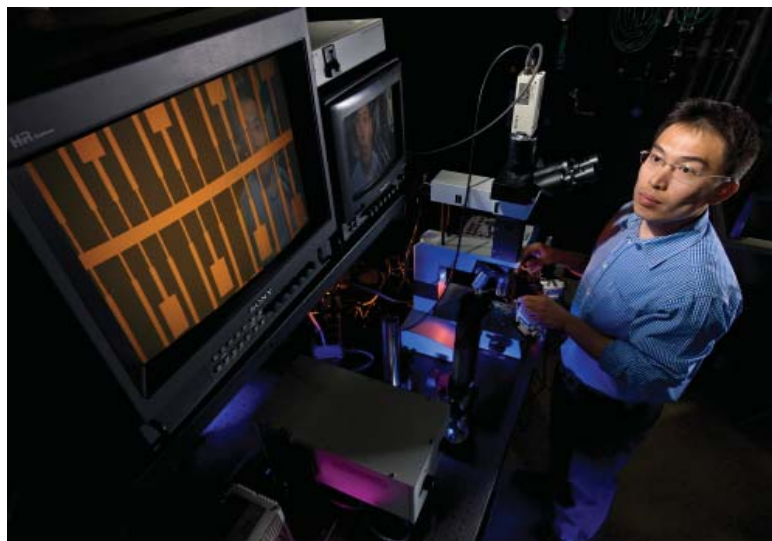




technology opportunity

Nanoengineered Thermal Materials

Thermal conductors for integrated circuits and devices can be made from carbon nanotube arrays.



The invention uses an embedded carbon nanotube array to provide one or more high-performance thermal conductors for applications that require large heat dissipation.

A method has been developed for providing for thermal conduction using an array of carbon nanotubes (CNTs). An array of vertically oriented CNTs is grown on a substrate having high thermal conductivity, and interstitial regions between adjacent CNTs in the array are partly or wholly filled with a filler material having a high thermal conductivity so that at least one end of each CNT is exposed. The exposed end of each CNT is pressed against a surface of an object from which heat is to be removed. The CNT-filler composite adjacent to the substrate provides improved mechanical strength to anchor CNTs in place, and also serves as a heat spreader to improve diffusion of heat flux from the smaller volume (CNTs) to a larger heat sink. The invention uses an embedded carbon nanotube array to provide one or more high-performance thermal conductors for applications that require large heat dissipation. This approach also improves the mechanical strength of carbon nanotubes (CNTs) so that the CNT array can remain stable and make good contact to the surface of objects that generate a large amount of heat, through use of reversible buckling and bending of exposed portions of the CNTs. The extremely high thermal conductivity along a carbon nanotube axis is employed to transfer heat away from hot spots in a component or device. Copper and other high-thermal-conductivity materials are deposited to fill interstitial regions or gaps in the first part of a CNT array.

Technology in Detail

The fabrication involves four steps: (1) Substantially vertically aligned CNT arrays with a preferred length of from 1 to 50 microns are grown on a solid substrate (serving as a heat sink) that has good thermal conductivity, such as Si wafers and metal blocks/films; (2) a first portion of, or all of, interstitial spaces between adjacent CNTs are filled with high-thermal-conductivity materials such as Cu, Ag, Au, Pt, or doped Si by chemical vapor deposition (CVD), physical vapor deposition (PVD), plasma deposition, ion sputtering, electrochemical deposition, or casting from liquid phase; (3) filler materials are removed from a second portion of the interstitial spaces by mechanical polishing (MP), chemical mechanical polishing (CMP), wet chemical etching, electrochemical etching, or dry plasma etching so that the top portion of the CNT array is exposed, with the bottom portion remaining embedded in the filler materials; and (4) the embedded CNT array is applied against an object that is to be cooled. CNTs can reversibly buckle or bend one-by-one under low loading pressure so that a CNT can make maximum contact with the object to be cooled, even an object with a very rough surface.

Heat can be effectively transferred from the contacting spots along the tube axis to the filler materials as well as the substrates. The filler materials play two critical roles: improving the mechanical stability and maximizing the thermal conductivity. Choosing highly thermal conductive materials as the filler matrix maximizes the heat transfer from the contact spots to the substrate (i.e., the heat sink or cooling reservoir). An embedded CNT array can be reused without damage or compromise of its heat transport characteristics, in contrast to an approach that relies upon eutectic bonding.

Patents

This technology has been patented (U.S. Patent 7,784,531).

Licensing and Partnering Opportunities

This technology is part of NASA's Innovative Partnerships Program, which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to inquire about licensing possibilities for this technology for commercial applications.

For More Information

If you would like more information about this technology, please contact:

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